PATENT ABSTRACTS OF JAPAN

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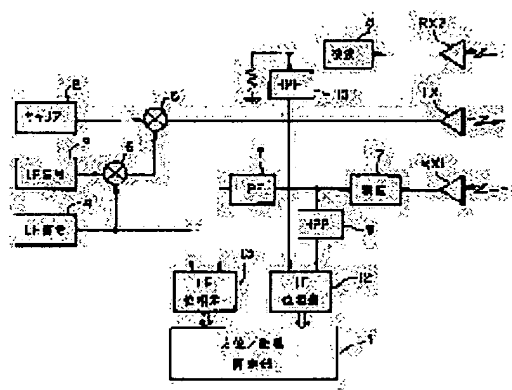
(54) RADAR EQUIPMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To precisely calculate the direction of a reflector by receiving the reflected wave of the reflector by a radiation wave by a pair of receiving means, and determining the difference in propagating stroke length of both the means from the reflector from the difference in phase or amplitude of the reflected wave received by both the means.



SOLUTION: A reflected AM signal by a forward vehicle or a walker is received by receiving antennas RX1, RX2, and received signals are detected by wave detecting circuits 7, 8, respectively. The outputs of the circuits 7, 8 are inputted to an IF signal phase difference detecting circuit 12 through HPF 9, 10, respectively, and the detected phase difference is transmitted to a direction/distance calculating part 1. The calculating part 1 multiplies the phase difference by an IF wavelength to determine the propagating stroke length, and calculates the direction of a reflector from this and the earthing space between the antennas RX1, RX2. A part of the output of the circuit 7 passed through an LPF 11 and the LF signal from an LF signal generating circuit 4 are inputted to an LF signal phase difference detecting circuit 13, and the detected phase difference is transmitted to the calculating part 1. The calculating part lmultiplies the phase difference by the LF wavelength to determine the propagating stroke length, and calculates the distance to the reflector.

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CLAIMS

[Claim(s)]
[Claim 1] A wave-motion transmitting means to transmit the wave motion of either an electric wave, a light wave or an acoustic wave (an ultrasonic acoustic wave is included), The 1st and the 2nd reflected wave receiving means of receiving the reflected wave of the wave motion which was transmitted from said wave-motion transmitting means, and was reflected by the reflector while maintaining predetermined spacing and having been arranged, Merit's difference is detected. the said 1st [from the difference at the phase / of the reflected wave which the said 1st and 2nd reflected wave receiving means received /, amplitude, frequency, or appearance time], and 2nd reflected wave receiving means -- respectively -- ** -- said wave propagation between said reflectors -- a course -- this detected propagation -- a course -- the radar installation characterized by having a means to calculate bearing of said reflector from merit's difference.
[Claim 2] It is the radar installation which said wave motion is an electric wave or an acoustic wave, and is characterized by using at least one side of the said 1st and 2nd reflected wave receiving means also [means / said / wave-motion transmitting] in claim 1.
[Claim 3] It is the radar installation which is the electric wave, light wave, or acoustic wave by which amplitude modulation of said wave motion was carried out in claim 1 or 2, and is characterized by detecting said propagation path difference from the difference of the phase of the modulated wave extracted from said reflected wave.
[Claim 4] It is the radar installation which a frequency is the electric wave or acoustic wave by which said wave motion changes with time amount in claim 1 or 2, and by which frequency modulation was carried out, and is characterized by detecting said propagation path difference from the difference of the frequency of said reflected wave.
[Claim 5] It is the radar installation which said wave motion is pulse-like an electric wave, a light wave, or an acoustic wave in claim 1 or 2, and is characterized by detecting said propagation path difference from the difference at the appearance time of said reflected wave.
[Claim 6] A wave-motion transmitting means to transmit the wave motion of either an electric wave, a light wave or an acoustic wave (an ultrasonic acoustic wave is included), The 1st, the 2nd, and the 3rd reflected wave receiving means of receiving the reflected wave of the wave motion which was transmitted from said wave-motion transmitting means, and was reflected by the reflector while maintaining predetermined spacing and having been arranged in three dimensions, Said 1st [the], the 2nd, the phase of the reflected wave which the 3rd reflected wave receiving means received, the said 1st [from the difference at the amplitude frequency, or appearance time], 2nd, and 3rd reflected wave receiving means -- respectively -- ** -- said wave propagation between said reflectors -- a course -- merit's difference -- detecting -- this detected propagation -- a course -- the radar installation characterized by having a means to calculate three-dimensional bearing of said reflector from merit's difference.
[Claim 7] A wave-motion transmitting means to transmit the wave motion of either an electric wave, a light wave or an acoustic wave (a supersonic wave is included), The 1st and the 2nd reflected wave receiving means of receiving the reflected wave of the wave motion which was transmitted from said wave-motion transmitting means, and was reflected by the reflector while maintaining predetermined spacing and having been arranged, Merit's difference is detected. the 1st [from the difference at the phase / of the reflected wave which the said 1st and 2nd reflected wave receiving means received /, amplitude frequency, or appearance time], and 2nd reflected wave receiving means -- respectively -- ** -- said wave propagation between said reflectors -- a course -- this detected propagation -- a course -- the radar installation characterized by having a means to calculate bearing of said reflector from merit's difference, and a distance calculation means to detect the propagation duration to said reflector of said wave motion, and to calculate the distance to this reflector based on this.
[Claim 8] It is the radar installation characterized by detecting the phase of the reflected wave to which one side of the said 1st and 2nd reflected wave receiving means received said distance calculation means in claim 7, and the wave motion which said wave-motion transmitting means transmits, the amplitude, a frequency, or the propagation duration

from the difference at the appearance time to said reflector of said wave motion.
[Claim 9] A wave-motion transmitting means to transmit the wave motion of either an electric wave, a light wave or an acoustic wave (an ultrasonic acoustic wave is included), The 1st, the 2nd, and the 3rd reflected wave receiving means of receiving the reflected wave of the wave motion which was transmitted from said wave-motion transmitting means, and was reflected by the reflector while maintaining predetermined spacing and having been arranged in three dimensions, Said 1st [the], the 2nd, the phase of the reflected wave which the 3rd reflected wave receiving means received, Merit's difference is detected. the said 1st [from the difference at the amplitude, frequency, or appearance time], 2nd, and 3rd reflected wave receiving means -- respectively -- ** -- said wave propagation between said reflectors -- a course -- this detected propagation -- a course -- the radar installation characterized by having a distance calculation means to detect the propagation duration to said reflector of a means to calculate three-dimensional bearing of said reflector from merit's difference, and said wave motion, and to calculate the distance to this reflector based on this.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Generally this invention relates to the radar installation which raised the detection precision of a direction especially about the radar installation for realizing the collision warning system of a car etc.
[0002]
[Description of the Prior Art] In order to realize the collision warning equipment of a car etc., various kinds of radar installations for mount have been developed. This kind of radar installation for mount receives the reflected wave which this transmission wave collided with reflectors, such as a precedence car and a pedestrian, and generated after transmitting wave motion, such as an electric wave, a light wave, and an acoustic wave, ahead of a car etc. The propagation duration which took between this radar installation and reflector for the wave motion to go is detected from the difference at the phase [between this reflected wave that received, and the original transmission wave], amplitude, frequency, or appearance time. This detected propagation duration, It is constituted so that the distance from the propagation velocity of a proper to a reflector may be calculated to the wave motion.
[0003] the above -- measurement of a fundamental distance -- in addition, the direction ("bearing" is called) seen from the self-car of the reflector which produced reflected waves, such as a precedence car and a pedestrian along the route, is measured, and the judgment of whether based on this bearing, each reflector can become the failure of transit is performed. For measurement of this bearing, the wave motion is extracted in the shape of a narrow beam, and it is necessary to scan this in the direction of a core of a beam, and the direction of a right angle.
[0004] Conventionally, when the scan of this beam uses a laser beam as wave motion, the mechanical thing which rotates a polygon mirror is used. On the other hand, since it is difficult to carry out high-speed rotation of the comparatively large-sized antenna equipment containing a reflecting mirror etc. mechanically when using the electric wave of a millimeter wave band as wave motion, the radiation direction of an electric wave was shifted little by little, the a large number antenna was arranged, and the thing of an electronic formula which these are switched [thing] in time sharing and operates them has been used.
[0005]
[Problem(s) to be Solved by the Invention] In using an electric wave as wave motion conventionally, it has arranged many antennas for the scan of the beam for bearing detection of a reflector. For this reason, there is a problem that the whole antenna equipment becomes at an expensive price and large-sized. Therefore, one purpose of this invention is to provide the basis of a cheap and small configuration of having used a small number of antenna more with the radar installation which can detect bearing of a reflector with high degree of accuracy.
[0006]
[Means for Solving the Problem] A wave-motion transmitting means by which the radar installation of this invention transmits the wave motion of either an electric wave, a light wave or an acoustic wave (a supersonic wave is included), The 1st and the 2nd reflected wave receiving means of receiving the reflected wave of the wave motion which was transmitted from said wave-motion transmitting means, and was reflected by the reflector while maintaining predetermined spacing and having been arranged, Merit's difference is detected. the 1st [from the difference at the phase / of the reflected wave which the said 1st and 2nd reflected wave receiving means received /, amplitude frequency, or appearance time], and 2nd reflected wave receiving means -- respectively -- ** -- said wave propagation between said reflectors -- a course -- this detected propagation -- a course -- it has a means to calculate bearing of said reflector from merit's difference.
[0007]
[Embodiment of the Invention] According to the gestalt of operation of this invention, the wave motion transmitted

from a wave-motion transmitting means is an electric wave or an acoustic wave, and at least one side of the 1st and 2nd reflected wave receiving means is used also [means / this / wave-motion transmitting]. According to the gestalt of other operations of this invention, the wave motion transmitted and received is the electric wave, light wave, or acoustic wave by which amplitude modulation was carried out, and propagation path difference is detected from the difference of the phase of the modulated wave extracted from the reflected wave received by each receiving means. Further, according to the gestalt of other operations, the wave motion of this invention transmitted and received is the electric wave or acoustic wave by which a frequency changes with time amount and by which frequency modulation was carried out, and propagation path difference is detected from the difference of the frequency of the reflected wave received by each receiving means.
[0008]
[Example] Drawing 1 is the block diagram showing the configuration of AM radar installation of one example of this invention. The antenna only for transmission, and RX1 and RX2 TX The antenna of reception only, 1 a carrier (subcarrier) generating circuit and 3 for bearing / distance calculation section, and 2 IF (intermediate frequency) signal generating circuit, 4 -- for a detector circuit, and 9 and 10, as for a low pass filter circuit (LPF) and 12, a high pass filter circuit (HPF) and 11 are [an amplitude modulation circuit, and 7 and 8 / LF (low frequency) signal generating circuit, and 5 and 6 / an IF signal phase contrast detector and 13] LF signal phase contrast detectors.
[0009] The carrier generating circuit 2 is 60GHz. The carrier of the RF of the millimeter wave band of extent is generated, and the modulating-signal-ed input terminal of an amplitude modulation circuit 6 is supplied. The IF signal generating circuit 3 generates the IF signal of 300 MHz (wavelength of 1m) extent, and supplies it to the modulating-signal-ed input terminal of an amplitude modulation circuit 5. The LF signal generating circuit 4 generates LF signal of 1.5 MHz (wavelength of 200m) extent, and supplies it to the modulating-signal input terminal of an amplitude modulation circuit 5. The IF signal supplied to the modulating-signal-ed input terminal of an amplitude modulation circuit 5 carries out amplitude modulation of the carrier which amplitude modulation is carried out, is supplied to the modulating-signal input terminal of an amplitude modulation circuit 6, and is supplied to the modulating-signal-ed input terminal by LF signal supplied to the modulating-signal input terminal.
[0010] The carrier (AM signal) which received the amplitude modulation outputted from an amplitude modulation circuit 6 is transmitted to space, such as the front of a car, from the antenna TX only for transmission. It is reflected by reflectors, such as a car ahead of a car, and a pedestrian, and a part of AM signal transmitted from the antenna TX only for transmission follows a transmitting path and the path of the reverse sense, and it is received by the antennas RX1 and RX2 of reception only as a reflective AM signal. By being detected in detector circuits 7 and 8, respectively, a carrier signal is removed and it restores to the reflective AM signal received by antennas RX1 and RX2 to the IF signal which received the amplitude modulation by LF signal.
[0011] The recovery signal outputted from a detector circuit 7 is supplied to the high pass filter circuit 9 and the low pass filter circuit 11. In the high pass filter circuit 9, LF signal component of low frequency is removed from a recovery signal, it becomes only IF signal component which is a RF, and one input terminal of the IF signal phase contrast detector 12 is supplied. It is outputted to the input terminal of another side of this IF signal phase contrast detector 12 from a detector circuit 8, and the recovery signal which LF signal component of low frequency was removed in the high pass filter circuit 10, and became only IF signal component of a RF is supplied to it.
[0012] It is received by each of the antennas RX1 and RX2 of reception only, and the IF signal phase contrast detector 12 detects the phase contrast of the about [wavelength 1m] IF signal to which it restored, and notifies a detection result to bearing / distance calculation section 1. By carrying out the multiplication of the wavelength of 1m of an IF signal to the phase contrast of the IF signal notified from the IF signal phase contrast detector 12, bearing / distance calculation section 1 calculates the propagation path difference of a reflected wave, and calculates label-bearing which produced the reflected wave from installation spacing of the propagation path difference of this calculated 1m [a maximum of] reflected wave, and the antennas RX1 and RX2 of reception only.
[0013] A part of recovery signal outputted from a detector circuit 7 is supplied to the low pass filter circuit 11, and IF signal component of a RF is removed, and it serves as only LF signal component of low frequency, and is supplied to one input terminal of the phase contrast detector 13 of LF signal. LF signal generated in the LF signal generating circuit 4 is supplied to the input terminal of another side of this LF signal phase contrast detector 13.
[0014] It is received by the antenna RX 1 of reception only, and LF signal phase contrast detector 13 detects the phase contrast of LF signal to which it restored, and LF signal supplied from the LF signal generating circuit 4, and notifies a detection result to bearing / distance calculation section 1. propagation of the round trip between the targets of the AM signal emitted when bearing / distance calculation section 1 carried out the multiplication of the wavelength of 200m of LF signal to the phase contrast of LF signal notified from LF signal phase contrast detector 13 -- a course -- merit is

calculated and the distance to a 100m [a maximum of] target is calculated by making this into one half.
[0015] The antenna TX only for transmission and two antennas RX1 and RX2 of reception only are arranged so that it may illustrate to (**) of drawing 5 , (**), and (Ha). That is, the antenna TX only for transmission turns [part / for the core of the anterior part of a car body] to the straight front of a car, and it is arranged, and mutually, only distance D (typically 1m) separates on the both sides, and two antennas RX1 and RX2 of reception only are arranged at them. the case where the reflectors T, such as a car, a pedestrian, etc. who produce the reflected wave of the AM signal transmitted from the antenna TX only for transmission, exist ahead of [straight] a car so that it may illustrate to drawing 5 (b) -- propagation of the reflected wave from Reflector T to the antennas RX1 and RX2 of each reception only -- a course serves as the equal value R and propagation path difference becomes zero.
[0016] the case where Reflector T exists in the method of the forward right of a car so that it may illustrate to (b) of drawing 5 -- propagation of the reflected wave from this reflector T to the antenna RX 1 of reception only -- a course -- merit -- propagation of the reflected wave from this reflector T to the antenna RX 2 of reception only -- a course -- only delta becomes long from Merit R. this course -- it is detected by comparing the phase of the IF signal by which merit's difference delta is included in the reflected wave received by the antennas RX1 and RX2 of each reception only.
[0017] a radio propagation rate -- about -- 3x108 m/sec it is -- since -- a duration for an electric wave to spread the distance of deltam -- tau=(delta/3)10-8sec = (delta/0.3) nsec It becomes. In order to detect this time difference according to the phase contrast of an IF signal, the frequency f of an IF signal should just be f<=1/tau= 0.3/delta GHz. 1m, then the frequency f of an IF signal are 330 MHz about delta. What is necessary is just the following.
[0018] the case where Reflector T exists in the method of the forward right of a car so that it may illustrate to (Ha) of drawing 5 -- propagation of the reflected wave from this reflector T to the antenna RX 1 of reception only -- a course -- merit -- propagation of the reflected wave from this reflector T to the antenna RX 2 of reception only -- a course -- only delta becomes short from Merit R. this propagation -- a course -- it is detected by comparing the phase of the IF signal by which merit's difference (- delta) is included in the reflected wave received by the antennas RX1 and RX2 of each reception only.
[0019] By carrying out the multiplication of the wavelength of 1m of an IF signal to the phase contrast of the IF signal notified from the IF signal phase contrast detector 12, bearing / distance calculation section 1 calculates propagation path difference **deltam of a 1m [a maximum of] reflected wave which was illustrated to drawing 5 , and calculates bearing of the reflector which produced the reflected wave from the installation spacing Dm of this calculated propagation path difference and the antennas RX1 and RX2 of reception only. In fact, in order to shorten calculation time amount, the propagation path difference delta and the distance R to the installation spacing D and the target of an antenna of reception only are given, Azimuth theta is beforehand searched for by calculation or plot, this is stored in the address defined with the combination of the above delta of ROM, and D and R, and it has composition which reads this.
[0020] Drawing 6 is a conceptual diagram for explaining how to search for the azimuth theta of a reflector mentioned above by plot. 2 point P1 which left only D to the symmetry, and P2 are set as the surroundings of Zero O, and it centers on one P1 of these. The radii of a radius R The radii of a radius (R+delta) are drawn centering on another side P2, respectively, the segment which connects the intersection P3 and Zero O of both radii is lengthened, and this segment and perpendicular (one-point ****) stood to segment P1P2 at Zero O, and the include angle theta to make are measured. An example of the result is shown in the following table 1.
[Table 1]

δ \ R	10m	20m	30m	40m	50m	60m	70m	80m
+0.1	5°44′47″	5°44′29″	5°44′25″	5°44′23″	5°44′24″	5°44′23″	5°44′23″	5°44′22″
+0.2	11°33′3″	11°32′26″	11°32′21″	11°32′19″	11°32′17″	11°32′17″	11°32′16″	11°32′16″
+0.3	17°28′39″	17°27′47″	17°27′40″	17°27′35″	17°27′34″	17°27′33″	17°27′33″	17°27′32″
+0.4	23°36′12″	23°35′3″	23°34′58″	23°34′53″	23°34′51″	23°34′50″	23°34′49″	23°34′49″
+0.5	30°1′46″	30°0′27″	30°0′20″	30°0′14″	30°0′11″	30°0′11″	30°0′10″	30°0′9″
+0.6	36°54′9″	36°52′44″	36°52′35″	36°52′28″	36°52′26″	36°52′24″	36°52′24″	36°52′23″
+0.7	44°27′38″	44°26′7″	44°26′4″	44°25′58″	44°25′54″	44°25′53″	44°25′52″	44°25′52″
+0.8	53°9′43″	53°8′19″	53°8′19″	53°8′13″	53°8′10″	53°8′9″	53°8′8″	53°8′7″
+0.9	64°11′2″	64°9′50″	64 10′6″	64°10′1″	64°9′59″	64°9′58″	64°9′57″	64°9′57″

[0021] If the result of Table 1 is analyzed, it will be outside anticipation and very significant information will be acquired. If the radio propagation path difference delta becomes settled, even if this will change over the large range that the distance R to a reflector is from 10m to 80m, Azimuth theta is the point of hardly changing. For example, the propagation path difference delta For the label-azimuth theta, when it is 0.3m, even if the distance R to a reflector is 17o28(degree)'(minute)39" (second) in 10m and the distance R to a target changes to 80m, Azimuth theta is 17o 27' 32". It is 1' slightly. Extent change is only carried out. Thus, the dependency to the distance R of the label-azimuth theta detected from radio propagation path difference can be disregarded within the limits of a measurement error.
[0022] Therefore, the calculation value of the azimuth theta of a reflector is stored in the address corresponding to the radio propagation path difference in ROM as a numeric value for which it depends only on propagation path difference regardless of the distance R to this target, and the approximation-approach read from the address corresponding to the propagation path difference which detected each numeric value can also be adopted.
[0023] LF signal is theoretically extracted also from the reflected wave which received with the antenna RX 2 of reception only using a low pass filter circuit. The distance (R+delta) of this antenna RX 2 and reflector is calculated from the phase contrast of this and LF signal outputted from the LF signal generating circuit 4. subtracting the distance R of the antenna RX 1 and reflector which were calculated based on the detection result of LF phase contrast circuit 13 from this calculation value -- propagation -- a course -- merit's difference delta is reckonable. However, in fact, since the detection precision of the distance R from an antenna to a reflector (R+delta) is the value which is about **1m, it is thought almost impossible in the light of a Prior art by this approach to detect bearing.
[0024] the block diagram in which drawing 2 shows the configuration of FM radar installation of other examples of this invention -- it is -- 1 -- for a triangular wave signal generating circuit and 22, as for a mixer and 25, FM (frequency modulation) circuit, and 23 and 24 are [bearing / distance calculation section, and 2 / a carrier generating circuit and 21 / a selector and 26] fast-Fourier-transform (FFT) circuits.
[0025] The carrier generating circuit 2 is 60GHz. The carrier of the RF of the millimeter wave band of extent is generated, and the modulating-signal-ed input terminal of the FM circuit 22 is supplied. The amplitude generates the triangular wave signal of 1.5 MHz extent fluctuated linearly a fixed period, and supplies the triangular wave signal generating circuit 21 to the modulating-signal input terminal of the FM circuit 22. The frequency modulation by the triangular wave signal supplied to the modulating-signal input terminal is received, a frequency serves as FM signal fluctuated linearly, and the carrier of the millimeter wave band supplied to the modulating-signal-ed input terminal of the FM circuit 22 is transmitted ahead of a car from the antenna TX only for transmission.
[0026] It is reflected by reflectors, such as a precedence car and a pedestrian, and a part of FM signal transmitted from the antenna TX only for transmission follows a transmitting path and the path of the reverse sense, and it is received by the antennas RX1 and RX2 of reception only as a reflective FM signal. It is mixed in a mixer 23 and the reflective FM signal received by antennas RX1 and RX2 generates the beat signal of a frequency equal to the difference of the frequency produced from the propagation path difference of both FM signal. This beat signal is supplied to the fast-Fourier-transform circuit 26 through a selector 25, it is changed into frequency spectrum, and the frequency (beat frequency) of a beat signal is detected.

[0027] From the beat frequency detected by the fast-Fourier-transform conversion circuit 12, bearing / distance calculation section 1 calculates the propagation-time difference, therefore propagation path difference of a reflected wave FM signal, and calculates label-bearing which produced the reflected wave from installation spacing of the propagation path difference of this calculated reflective FM signal, and the antennas RX1 and RX2 of reception only.
[0028] It is mixed with FM signal which is supplied also to one input terminal of a mixer 24, and is supplied to an other-end child from the FM signal generating circuit 22, and a part of reflective FM signal outputted from the antenna RX 1 of reception only generates the beat signal of the frequency according to the propagation duration of a round trip of FM signal between reflectors. This beat signal is supplied to the fast-Fourier-transform circuit 26 through a selector 25, and is changed into frequency spectrum, and the frequency (beat frequency) of a beat signal is detected. the propagation duration of a round trip of beat frequency to FM signal with which bearing / distance calculation section 1 was detected by the fast-Fourier-transform conversion circuit 12, therefore propagation of a round trip -- a course -- merit is calculated and the distance to a target is detected by carrying out the multiplication of the one half of this calculation value at the velocity of light.
[0029] Drawing 3 is the block diagram showing the configuration of the pulse radar equipment of the example of further others of this invention, and, as for bearing / distance calculation section, and 31, an ultrasonic pulse generating circuit, and 32 and 33 is [1] pulse period difference detectors.
[0030] The ultrasonic pulse which the ultrasonic pulse generating circuit 31 generated is transmitted ahead of a car from the transducer TX only for transmission, and it is reflected by targets, such as a precedence car and a pedestrian, and the part follows a transmitting path and the path of the reverse sense, and is received by the transducers RX1 and RX2 of reception only as a reflective supersonic-wave pulse signal.
[0031] Mutual time difference is detected in the pulse period difference detector 32, and, as for the reflective supersonic-wave pulse signal received by transducers RX1 and RX2, a detection result is notified to bearing / distance calculation section 1. Bearing / distance calculation section 1 detects the propagation path difference of a reflective supersonic-wave pulse from the time difference of the notified pulse signal, and calculates label-bearing which produced the reflective supersonic-wave pulse from this and the installation distance between the transducers of reception only.
[0032] Time difference with the pulse signal which a part of reflective pulse signal outputted from the antenna RX 1 of reception only is supplied to one input terminal of the pulse period difference detector 33, and is supplied to an other-end child from the ultrasonic pulse signal generating circuit 31 is detected. Bearing / distance calculation section 1 which receives this detected time difference detect the propagation path difference of the round trip from the time difference of the notified pulse signal to the reflector of an ultrasonic pulse signal, and calculates the distance to a reflector based on this.
[0033] Drawing 4 is the block diagram showing the configuration of the example of further others of this invention, and, for 1, bearing / distance calculation section, and 41 are [a circulator, the antenna of transmission-and-reception common use / 43 / a beat frequency detecting element and TRX /, and RX of FM signal generating circuit and 42] the antennas of reception only. FM signal which the FM signal generating circuit 41 generated is supplied to the antenna TRX of transmission-and-reception common use through a circulator 42, and is transmitted ahead of a car from here. The reflective FM signal produced in the target is received by each of the antenna TRX of transmission-and-reception common use, and the antenna RX of reception only.
[0034] The reflective FM signal which the antenna TRX of transmission-and-reception common use received is supplied to the beat frequency detecting element 43 through a circulator 42. The reflective FM signal which the antenna RX of reception only received is also supplied to the beat frequency detecting element 43. As shown in drawing 7 , the antenna TRX of transmission-and-reception common use and the antenna RX of reception only detach only distance D, and are installed, and the reflective FM signal received by Antennas TRX and RX has the propagation path difference of only delta.
[0035] The beat frequency detecting element 43 consists of the mixers 23 and 24, the selector 25 and the fast-Fourier-transform circuit 26 which were illustrated to drawing 2 , and same circuit, detects the beat frequency corresponding to the propagation path difference delta of a reflective FM signal, and the beat frequency corresponding to the distance R to a reflector, and supplies them to bearing / distance calculation section 1. Bearing / distance calculation section 1 calculates bearing and distance of a reflector from the beat frequency supplied from the beat frequency detecting element 43.
[0036] As mentioned above, the configuration of explanation which separates and installs a generation-of-carriers circuit, and the amplitude / frequency modulation circuit in the example of drawing 1 and drawing 2 for convenience was illustrated. However, it is constituted by one as a generating circuit of an AM signal or FM signal by incorporating

variable capacitance diode etc. in fact in the oscillator circuit of the carrier of the millimeter wave band which makes a subject solid state oscillators, such as Gunn diode and an IMPATT diode.

[0037] Moreover, although the configuration which uses an electric wave and a supersonic wave as wave motion was illustrated, the laser pulse generated with the laser diode can be transmitted, and the configuration which transmits and receives the light wave of receiving a reflected wave by APD can also be adopted.

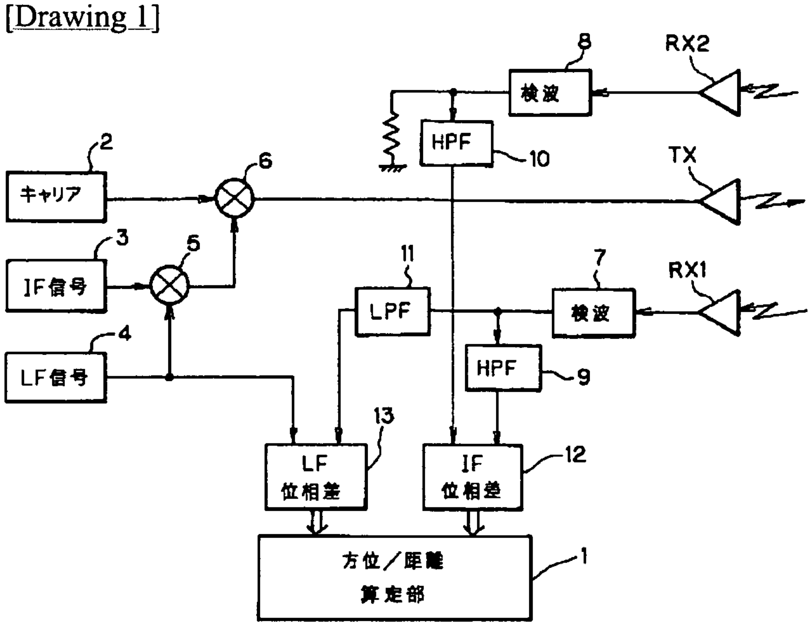
[0038] Furthermore, the configuration which detects bearing of the reflector within the 2-dimensional flat surface in which two receiving antennas are installed and these antennas are installed was illustrated. However, it can do considering as the configuration which detects three-dimensions-bearing of a reflector by arranging three receiving antennas in three dimensions.

[0039] As explained to the detail above, the radar installation of this invention Merit's difference is detected. from the difference at the phase [of the reflected wave which one pair of reflected wave receiving means received], amplitude, frequency, or appearance time -- respectively -- ** -- the propagation between reflectors -- a course -- this detected propagation -- a course -- since it is the configuration which calculates bearing of a reflector from merit's difference -- one pair of reflected wave receiving means -- the distance to a reflector -- calculating -- the propagation from the difference of this distance -- a course -- compared with the case where merit's difference is calculated, it is very highly precise and bearing of a reflector can be detected.

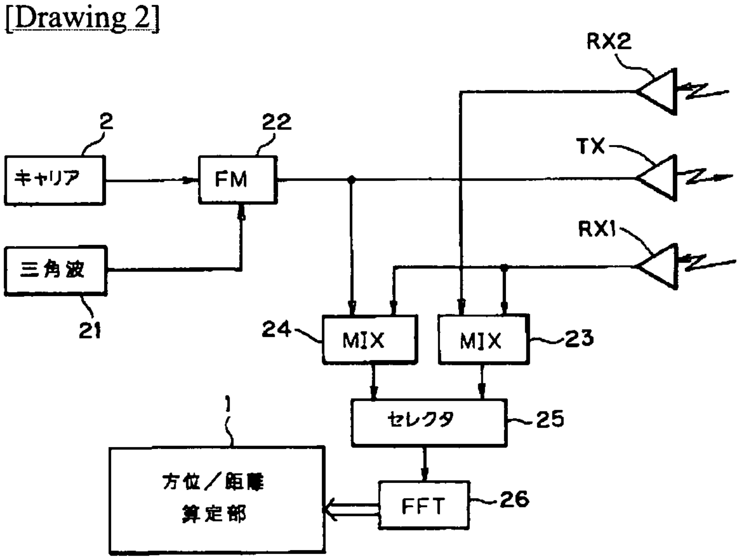
[Translation done.]

DRAWINGS

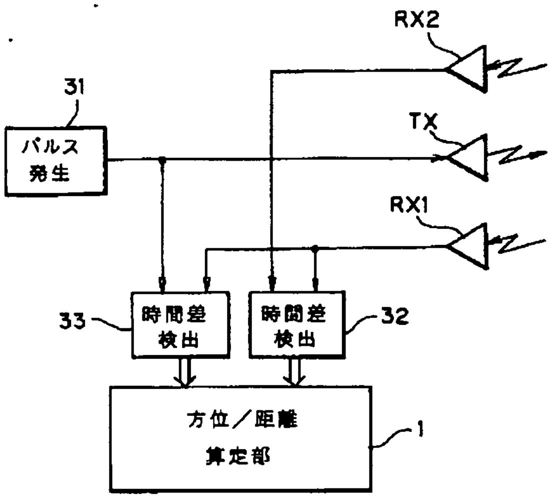
[Drawing 1]



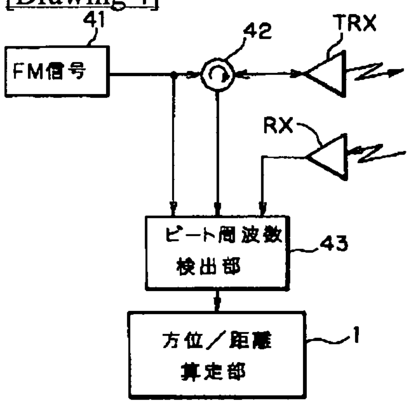
[Drawing 2]



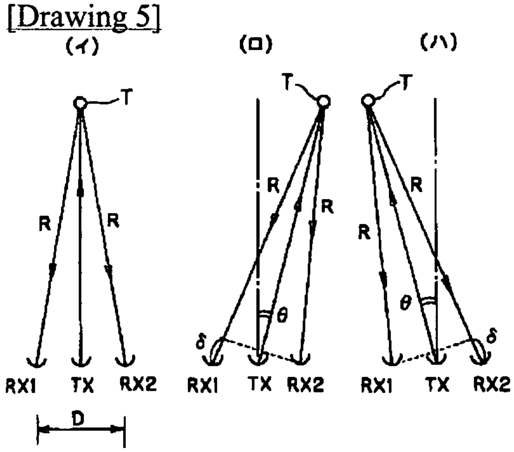
[Drawing 3]



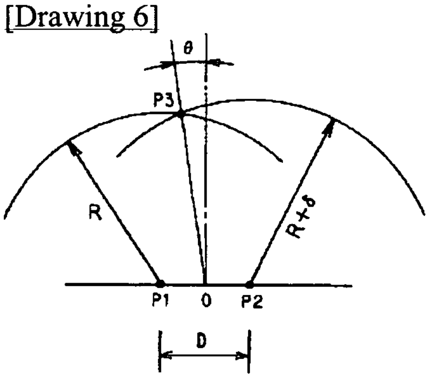
[Drawing 4]



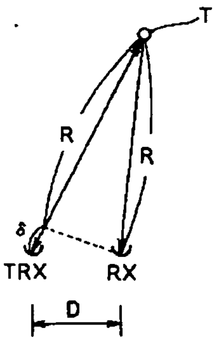
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]

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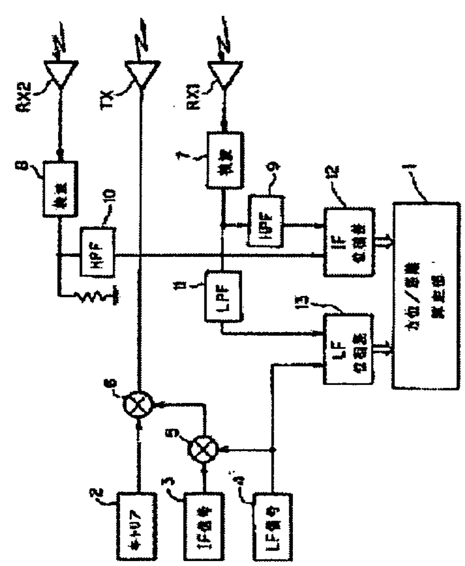
(54)【発明の名称】　レーダ装置

(57)【要約】
〔課題〕自装置から見た反射体の方位（方位）を高精度で検出可能なレーダ装置を提供する。
〔解決手段〕電波、光波又は音波（超音波を含む）のいずれかの波動を送信する波動送信手段（TX）と、所定の間隔を保って配置されると共に前記波動送信手段から送信され反射体で反射された波動の反射波を受信する第１，第２の反射波受信手段（RX1,RX2）と、これら第１，第２の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差からこれら第１，第２の反射波受信手段それぞれと前記反射体との間の前記波動の伝播行路長の差を検出し、この検出した伝播行路長の差から前記反射波の方位を算定する手段(7,8,9,10,11,12,13,1)とを備える。



【特許請求の範囲】
【請求項 1】電波、光波又は音波（超音波音波を含む）のいずれかの波動を送信する波動送信手段と、
所定の間隔を保って配置されると共に前記波動送信手段から送信され反射体で反射された波動の反射波を受信する第１，第２の反射波受信手段と、
前記第１，第２の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差から前記第１，第２の反射波受信手段のそれぞれと前記反射体との間の前記波動の伝播行路長の差を検出し、この検出した伝播行路長の差から前記反射体の方位を算定する手段とを備えたことを特徴とするレーダ装置。
【請求項 2】　請求項 1において、
前記波動は電波又は音波であ り、前記第１，第２の反射波受信手段の少なくとも一方は、前記波動送信手段と兼用されることを特徴とするレーダ装置。
【請求項 3】　請求項 1又は2において、
前記波動は振幅変調された電波、光波又は音波であ り、前記反射波から抽出された被変調波の位相の差から前記伝播行路差が検出されることを特徴とするレーダ装置。
【請求項 4】　請求項 1又は2において、
前記波動は周波数が時間と共に変化する周波数変調された電波又は音波であ り、前記反射波の周波数の差から前記伝播行路差が検出されることを特徴とするレーダ装置。
【請求項 5】　請求項 1又は2において、
前記波動はパルス状の電波、光波又は音波であ り、前記反射波の出現時点の差から前記伝播行路差が検出されることを特徴とするレーダ装置。
【請求項 6】電波、光波又は音波（超音波音波を含む）のいずれかの波動を送信する波動送信手段と、
所定の間隔を保って立体的に配置されると共に前記波動送信手段から送信され反射体で反射された波動の反射波を受信する第１，第２，第３の反射波受信手段と、　前記第１，第２，第３の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差から前記第１，第２，第３の反射波受信手段のそれぞれと前記反射体との間の前記波動の伝播行路長の差を検出し、この検出した伝播行路長の差から前記反射体の立体的な方位を算定する手段とを備えたことを特徴とするレーダ装置。
【請求項 7】電波、光波又は音波（超音波を含む）のいずれかの波動を送信する波動送信手段と、
所定の間隔を保って配置されると共に前記波動送信手段から送信され反射体で反射された波動の反射波を受信する第１，第２の反射波受信手段と、
前記第１，第２の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差から第１，第２の反射波受信手段のそれぞれと前記反射体との間の前記波動の伝播行路長の差を検出し、この検出した伝播行路長の差から前記反射体の方位を算定する手段と、
前記波動の前記反射体までの伝播所要時間を検出しこれに基づきこの反射体までの距離を算定する距離算定手段とを備えたことを特徴とするレーダ装置。
【請求項 8】　請求項 7において、
前記距離算定手段は、前記第１，第２の反射波受信手段のうちの一方が受信した反射波と、前記波動送信手段が送信する波動の位相、振幅、周波数又は出現時点の差から前記波動の前記反射体までの伝播所要時間を検出することを特徴とするレーダ装置。
【請求項 9】電波、光波又は音波（超音波音波を含む）のいずれかの波動を送信する波動送信手段と、
所定の間隔を保って立体的に配置されると共に前記波動送信手段から送信され反射体で反射された波動の反射波を受信する第１，第２，第３の反射波受信手段と、　前記第１，第２，第３の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差から前記第１，第２，第３の反射波受信手段のそれぞれと前記反射体との間の前記波動の伝播行路長の差を検出し、この検出した伝播行路長の差から前記反射体の立体的な方位を算定する手段と前記波動の前記反射体までの伝播所要時間を検出しこれに基づきこの反射体までの距離を算定する距離算定手段とを備えたことを特徴とするレーダ装置。

【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、一般的には、車両の衝突警報システム などを実現するためのレーダ装置に関するものであ り、特に、方向の検出精度を高めたレーダ装置に関するものであ る。
【０００２】
【従来の技術】車両の衝突警報装置などを実現するために、各種の車載用レーダ装置が開発されてきている。この種の車載用レーダ装置は、電波、光波、音波などの波動を車両の前方などに送信したのちこの送信波が先行車両や歩行者などの反射体に衝突して発生した反射波を受信し、この受信した反射波と元の送信波との間の位相、振幅、周波数あ るいは出現時点の差からこのレーダ装置と反射体との間を波動が往復するのに要した伝播所要時間を検出し、この検出した伝播所要時間と、波動に固有の伝播速度とから反射体までの距離を算定するように構成されている。
【０００３】上記基本的な距離の測定に加えて、先行車両や、沿道の歩行者などの反射波を生じさせた反射体の自車両から見た方向（「方位」と称する）を測定し、この方位に基づき各反射体が走行の障害になり得るか否かの判定が行われる。この方位の測定のためには、波動を細いビーム 状に絞り、これをビーム の中心方向と直角の方向に走査することが必要になる。
【０００４】従来、このビーム の走査は、波動としてレーザ光を利用する場合にはポリゴンミラーを回転させる機械式のものが利用されてきた。これに対して、波動と

してミリ波帯の電波を使用する場合には、反射鏡などを含む比較的大型のアンテナ装置を機械的に高速回転させることが困難なため、電波の放射方向を少しずつずらして多数アンテナを配列し、これらを時分割的に切り換えて動作させる電子式のものが使用されてきた。

【０００５】

【発明が解決しようとする課題】従来、波動として電波を使用する場合には、反射体の方位検出用のビーム の走査のために多数のアンテナを配列している。このため、アンテナ装置全体が高価・大型になるという問題がある。従って、本発明の一つの目的は、より少数のアンテナを使用した安価・小型な構成のもとに反射体の方位を高精度で検出できるレーダ装置を提供することにある。

【０００６】

【課題を解決するための手段】本発明のレーダ装置は、電波、光波又は音波（超音波を含む）のいずれかの波動を送信する波動送信手段と、所定の間隔を保って配置されると共に前記波動送信手段から送信され反射体で反射された波動の反射波を受信する第１，第２の反射波受信手段と、前記第１，第２の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差から第１，第２の反射波受信手段のそれぞれと前記反射体との間の前記波動の伝播行路長の差を検出し、この検出した伝播行路長の差から前記反射体の方位を算定する手段とを備えている。

【０００７】

【発明の実施の形態】本発明の実施の形態によれば、波動送信手段から送信される波動は電波又は音波であり、第１，第２の反射波受信手段の少なくとも一方はこの波動送信手段と兼用される。本発明の他の実施の形態によれば、送受信される波動は振幅変調された電波、光波又は音波であり、各受信手段に受信された反射波から抽出された被変調波の位相の差から伝播行路差が検出される。本発明の更に他の実施の形態によれば、送受信される波動は周波数が時間と共に変化する周波数変調された電波又は音波であり、各受信手段に受信された反射波の周波数の差から伝播行路差が検出される。

【０００８】

【実施例】図１は、本発明の一実施例のＡＭレーダ装置の構成を示すブロック図であり、ＴＸは送信専用のアンテナ、ＲＸ１とＲＸ２は受信専用のアンテナ、１は方位／距離算定部、２はキャリア（搬送波）発生回路、３はＩＦ（中間周波）信号発生回路、４はＬＦ（低周波）信号発生回路、５，６は振幅変調回路、７，８は検波回路、９，１０は高域通過濾波回路（ＨＰＦ）、１１は低域通過濾波回路（ＬＰＦ）、１２はＩＦ信号位相差検出回路、１３はＬＦ信号位相差検出回路である。

【０００９】キャリア発生回路２は、６０GHz 程度のミリ波帯の高周波のキャリアを発生し、振幅変調回路６の被変調信号入力端子に供給する。ＩＦ信号発生回路３は、３００MHz（波長１ｍ）程度のＩＦ信号を発生し、振幅変調回路５の被変調信号入力端子に供給する。ＬＦ信号発生回路４は、１．５MHz（波長２００ｍ）程度のＬＦ信号を発生し振幅変調回路５の変調信号入力端子に供給する。振幅変調回路５の被変調信号入力端子に供給されたＩＦ信号は、その変調信号入力端子に供給されるＬＦ信号によって振幅変調されて振幅変調回路６の変調信号入力端子に供給され、その被変調信号入力端子に供給されるキャリアを振幅変調する。

【００１０】振幅変調回路６から出力される振幅変調を受けたキャリア（ＡＭ信号）は、送信専用のアンテナＴＸから車両の前方などの空間に送信される。送信専用のアンテナＴＸから送信されたＡＭ信号の一部は、車両の前方の車両や歩行者などの反射体で反射され、送信経路と逆向きの経路を辿って反射ＡＭ信号として受信専用のアンテナＲＸ１とＲＸ２とに受信される。アンテナＲＸ１，ＲＸ２に受信された反射ＡＭ信号は、それぞれ検波回路７と８とにおいて検波されることによってキャリア信号が除去され、ＬＦ信号による振幅変調を受けたＩＦ信号に復調される。

【００１１】検波回路７から出力される復調信号は、高域通過濾波回路９と低域通過濾波回路１１とに供給される。高域通過濾波回路９では、復調信号から低周波のＬＦ信号成分が除去され、高周波のＩＦ信号成分のみとなってＩＦ信号位相差検出回路１２の一方の入力端子に供給される。このＩＦ信号位相差検出回路１２の他方の入力端子には、検波回路８から出力され、高域通過濾波回路１０で低周波のＬＦ信号成分が除去されて高周波のＩＦ信号成分のみとなった復調信号が供給される。

【００１２】ＩＦ信号位相差検出回路１２は、受信専用のアンテナＲＸ１，ＲＸ２のそれぞれで受信され、復調された波長１ｍ程度のＩＦ信号の位相差を検出し、検出結果を方位／距離算定部１に通知する。方位／距離算定部１は、ＩＦ信号位相差検出回路１２から通知されたＩＦ信号の位相差にＩＦ信号の波長１ｍを乗算することによって反射波の伝播行路差を算定し、この算定した最大１ｍの反射波の伝播行路差と、受信専用のアンテナＲＸ１，ＲＸ２との設置間隔とから反射波を生じさせた標的の方位を算定する。

【００１３】検波回路７から出力される復調信号の一部は低域通過濾波回路１１に供給され、高周波のＩＦ信号成分が除去されて低周波のＬＦ信号成分のみとなってＬＦ信号の位相差検出回路１３の一方の入力端子に供給される。このＬＦ信号位相差検出回路１３の他方の入力端子には、ＬＦ信号発生回路４で発生されたＬＦ信号が供給される。

【００１４】ＬＦ信号位相差検出回路１３は、受信専用のアンテナＲＸ１で受信され、復調されたＬＦ信号と、ＬＦ信号発生回路４から供給されたＬＦ信号の位相差を検出し、検出結果を方位／距離算定部１に通知する。方

位／距離算定部１は、ＬＦ信号位相差検出回路１３から通知されたＬＦ信号の位相差にＬＦ信号の波長２００ｍを乗算することによって放射されたＡＭ信号の物標との間の往復の伝播行路長を算定し、これを半分にすることにより最大１００ｍの標的までの距離を算定する。

【００１５】送信専用のアンテナＴＸと、受信専用の２個のアンテナＲＸ１，ＲＸ２とは、図５の（イ），（ロ），（ハ）に例示するように配置されている。すなわち、車体の前部の中心部分に送信専用のアンテナＴＸが車両の真っ直ぐ前方を向いて配置されており、その両側に受信専用の２個のアンテナＲＸ１とＲＸ２とが互いに距離Ｄ（典型的には１ｍ）だけ離れて配置されている。図５（イ）に例示するように、送信専用のアンテナＴＸから送信されたＡＭ信号の反射波を生じさせる車両や歩行者などの反射体Ｔが車両の真っ直ぐ前方に存在する場合には、反射体Ｔから各受信専用のアンテナＲＸ１とＲＸ２までの反射波の伝播行路は等しい値Ｒとなり、伝播行路差はゼロになる。

【００１６】図５の（ロ）に例示するように、反射体Ｔが車両の右前方に存在する場合には、この反射体Ｔから受信専用のアンテナＲＸ１までの反射波の伝播行路長が、この反射体Ｔから受信専用のアンテナＲＸ２までの反射波の伝播行路長Ｒよりもδだけ長くなる。この行路長の差δが各受信専用のアンテナＲＸ１とＲＸ２に受信された反射波に含まれるＩＦ信号の位相を比較することによって検出される。

【００１７】電波の伝播速度はほぼ３×１０８ m／sec であるから、電波がδｍの距離を伝播するための所要時間はτ=(δ/3)１０−8sec = (δ/0.3) nsec となる。この時間差をＩＦ信号の位相差によって検出するには、ＩＦ信号の周波数ｆは、ｆ≦１／τ= 0.3／δ GHzであればよい。δを１ｍとすれば、ＩＦ信号の周波数ｆは330 MHz 以下であればよい。

【００１８】図５の（ハ）に例示するように、反射体Ｔが車両の右前方に存在する場合には、この反射体Ｔから受信専用のアンテナＲＸ１までの反射波の伝播行路長が、この反射体Ｔから受信専用のアンテナＲＸ２までの反射波の伝播行路長Ｒよりもδだけ短くなる。この伝播行路長の差（−δ）が各受信専用のアンテナＲＸ１とＲＸ２に受信された反射波に含まれるＩＦ信号の位相を比較することによって検出される。

【００１９】方位／距離算定部１は、ＩＦ信号位相差検出回路１２から通知されたＩＦ信号の位相差にＩＦ信号の波長１ｍを乗算することによって、図５に例示したような最大１ｍの反射波の伝播行路差±δｍを算定し、この算定した伝播行路差と、受信専用のアンテナＲＸ１，ＲＸ２との設置間隔Ｄｍとから、反射波を生じさせた反射体の方位を算定する。実際には、算定時間を短縮するため、伝播行路差δと受信専用のアンテナの設置間隔Ｄと標的までの距離Ｒを与えて方位角θを予め算定又は作図によって求めておき、これを、ＲＯＭの上記δとＤとＲとの組合せによって定義されるアドレスに格納しておき、これを読出すだけの構成となっている。

【００２０】図６は、上述した反射体の方位角θを作図によって求める方法を説明するための概念図である。原点Ｏのまわりに対称にＤだけ離れた２点Ｐ１，Ｐ２が設定され、その一方Ｐ１を中心にして半径Ｒの円弧が、他方Ｐ２を中心にして半径（Ｒ＋δ）の円弧がそれぞれ描かれ、両円弧の交点Ｐ３と原点Ｏとを連結する線分が引かれ、この線分と線分Ｐ１Ｐ２に原点Ｏで立てた垂線（一点鎖点）となす角度θが計測される。その結果の一例を以下の表１に示す。

【表１】

δ＼R	10m	20m	30m	40m	50m	60m	70m	80m
+0.1	5°44′47″	5°44′29″	5°44′26″	5°44′23″	5°44′24″	5°44′23″	5°44′23″	5°44′22″
+0.2	11°33′3″	11°32′26″	11°32′21″	11°32′19″	11°32′17″	11°32′17″	11°32′16″	11°32′16″
+0.3	17°28′39″	17°27′47″	17°27′40″	17°27′35″	17°27′34″	17°27′33″	17°27′33″	17°27′32″
+0.4	23°36′12″	23°35′3″	23°34′58″	23°34′53″	23°34′51″	23°34′50″	23°34′49″	23°34′49″
+0.5	30°1′46″	30°0′27″	30°0′20″	30°0′14″	30°0′11″	30°0′11″	30°0′10″	30°0′9″
+0.6	36°54′9″	36°52′44″	36°52′35″	36°52′28″	36°52′26″	36°52′24″	36°52′24″	36°52′23″
+0.7	44°27′38″	44°26′7″	44°26′4″	44°25′58″	44°25′54″	44°25′53″	44°25′52″	44°25′52″
+0.8	53°9′43″	53°8′19″	53°8′19″	53°8′13″	53°8′10″	53°8′9″	53°8′8″	53°8′7″
+0.9	64°11′2″	64°9′50″	64°10′6″	64°10′1″	64°9′59″	64°9′58″	64°9′57″	64°9′57″

【００２１】表１の結果を分析してみると、予想外のかつ極めて有意義な情報が得られる。これは、電波の伝播

行路差δが定まると、反射体までの距離Rが10mから80mまでという大幅な範囲にわたって変化しても、方位角θはほとんど変化しないという点である。例えば、伝播行路差δが0.3mの場合、反射体までの距離Rが10mでは標的の方位角θは17o（度）28′（分）39″（秒）であり、標的までの距離Rが80mに変化しても方位角θは17o 27′32″と僅かに1′程度変化するだけである。このように、電波の伝播行路差から検出される標的の方位角θの距離Rへの依存性は測定誤差の範囲内で無視することができる。

【0022】従って、反射体の方位角θの算定値をこの標的までの距離Rに関係なく伝播行路差のみに依存する数値として、ROM内の電波の伝播行路差に対応するアドレスに格納しておき、各数値を検出した伝播行路差に対応するアドレスから読出す近似的な方法を採用することもできる。

【0023】原理的には、受信専用のアンテナRX2で受信した反射波からも、低域通過濾波回路を用いてLF信号を抽出し、これとLF信号発生回路4から出力されるLF信号との位相差からこのアンテナRX2と反射体との距離（R＋δ）を算定し、この算定値からLF位相差回路13の検出結果に基づいて算定したアンテナRX1と反射体との距離Rを減算することにより伝播行路長の差δを算定することができる。しかしながら、実際には、アンテナから反射体までの距離Rや（R＋δ）の検出精度が±1m程度の値であるため、この方法によって方位を検出することは、従来の技術に照らしてほとんど不可能と考えられる。

【0024】図2は、本発明の他の実施例のFMレーダ装置の構成を示すブロック図であり、1は方位／距離算定部、2はキャリア発生回路、21は三角波信号発生回路、22はFM（周波数変調）回路、23，24はミキサー、25はセレクタ、26は高速フーリエ変換（FFT）回路である。

【0025】キャリア発生回路2は、60GHz程度のミリ波帯の高周波のキャリアを発生し、FM回路22の被変調信号入力端子に供給する。三角波信号発生回路21は、振幅が一定の周期で直線的に増減する1．5MHz程度の三角波信号を発生し、FM回路22の変調信号入力端子に供給する。FM回路22の被変調信号入力端子に供給されたミリ波帯のキャリアは、その変調信号入力端子に供給される三角波信号による周波数変調を受け、周波数が直線的に増減するFM信号となり、送信専用のアンテナTXから車両の前方に送信される。

【0026】送信専用のアンテナTXから送信されたFM信号の一部は、先行車両や歩行者などの反射体で反射され、送信経路と逆向きの経路を辿って反射FM信号として受信専用のアンテナRX1とRX2とに受信される。アンテナRX1，RX2に受信された反射FM信号は、ミキサー23において混合され、両FM信号の伝播行路差から生ずる周波数の差に等しい周波数のビート信号を発生する。このビート信号は、セレクタ25を介して高速フーリエ変換回路26に供給され、周波数スペクトルに変換され、ビート信号の周波数（ビート周波数）が検出される。

【0027】方位／距離算定部1は、高速フーリエ変換変換回路12で検出されたビート周波数から、反射波FM信号の伝播時間差従って伝播行路差を算定し、この算定した反射FM信号の伝播行路差と、受信専用のアンテナRX1，RX2との設置間隔とから反射波を生じさせた標的の方位を算定する。

【0028】受信専用のアンテナRX1から出力される反射FM信号の一部はミキサー24の一方の入力端子にも供給され、他方の端子にFM信号発生回路22から供給されるFM信号と混合され、反射体との間のFM信号の往復の伝播所要時間に応じた周波数のビート信号を発生させる。このビート信号は、セレクタ25を介して高速フーリエ変換回路26に供給されて周波数スペクトルに変換され、ビート信号の周波数（ビート周波数）が検出される。方位／距離算定部1は、高速フーリエ変換変換回路12で検出されたビート周波数から、FM信号の往復の伝播所要時間従って往復の伝播行路長を算定し、この算定値の半分を光速で乗算することにより標的までの距離を検出する。

【0029】図3は、本発明の更に他の実施例のパルスレーダ装置の構成を示すブロック図であり、1は方位／距離算定部、31は超音波パルス発生回路、32，33はパルス時間差検出回路である。

【0030】超音波パルス発生回路31が発生した超音波パルスは、送信専用のトランスデューサTXから車両の前方に送信され、その一部は先行車両や歩行者などの標的で反射され、送信経路と逆向きの経路を辿って反射超音波パルス信号として受信専用のトランスデューサRX1とRX2とに受信される。

【0031】トランスデューサRX1，RX2に受信された反射超音波パルス信号は、パルス時間差検出回路32において相互の時間差が検出され、検出結果が方位／距離算定部1に通知される。方位／距離算定部1は、通知されたパルス信号の時間差から反射超音波パルスの伝播行路差を検出し、これと受信専用のトランスデューサ間の設置距離とから反射超音波パルスを生じさせた標的の方位を算定する。

【0032】受信専用のアンテナRX1から出力される反射パルス信号の一部は、パルス時間差検出回路33の一方の入力端子に供給され、超音波パルス信号発生回路31から他方の端子に供給されるパルス信号との時間差が検出される。この検出された時間差を受ける方位／距離算定部1は、通知されたパルス信号の時間差から超音波パルス信号の反射体までの往復の伝播行路差を検出し、これに基づき反射体までの距離を算定する。

【００３３】図４は、本発明の更に他の実施例の構成を示すブロック図であり、１は方位／距離算定部、４１はＦＭ信号発生回路、４２はサーキュレータ、４３はビート周波数検出部、ＴＲＸは送受共用のアンテナ、ＲＸは受信専用のアンテナである。ＦＭ信号発生回路４１が発生したＦＭ信号は、サーキュレータ４２を通して送受共用のアンテナＴＲＸに供給され、ここから車両の前方に送信される。標的で生じた反射ＦＭ信号は、送受共用のアンテナＴＲＸと受信専用のアンテナＲＸのそれぞれに受信される。

【００３４】送受共用のアンテナＴＲＸが受信した反射ＦＭ信号は、サーキュレータ４２を通してビート周波数検出部４３に供給される。受信専用のアンテナＲＸが受信した反射ＦＭ信号もビート周波数検出部４３に供給される。図７に示すように、送受共用のアンテナＴＲＸと、受信専用のアンテナＲＸとは距離Ｄだけ離して設置されており、アンテナＴＲＸとＲＸとに受信された反射ＦＭ信号は、δだけの伝播行路差を有している。

【００３５】ビート周波数検出部４３は、図２に例示した、ミキサー２３，２４，セレクタ２５及び高速フーリエ変換回路２６と同様の回路から構成されており、反射ＦＭ信号の伝播行路差δに対応するビート周波数と、反射体までの距離Ｒに対応するビート周波数とを検出して方位／距離算定部１に供給する。方位／距離算定部１は、ビート周波数検出部４３から供給されたビート周波数から反射体の方位と距離を算定する。

【００３６】以上、説明の便宜上、図１と図２の実施例において、キャリアの発生回路と、振幅／周波数変調回路とを分離して設置する構成を例示した。しかしながら、実際には、ガンダイオードやインパットダイオードなどの固体発振素子を主体とするミリ波帯のキャリアの発振回路内に、可変容量ダイオードなどを組込むことにより、ＡＭ信号やＦＭ信号の発生回路として一体に構成される。

【００３７】また、波動として電波と超音波を使用する構成を例示したが、レーザダイオードで発生させたレーザパルスを送信し、反射波をＡＰＤで受信するという光波を送受信する構成を採用することもできる。

【００３８】さらに、２個の受信アンテナを設置してこれらのアンテナが設置される二次元平面内の反射体の方位を検出する構成を例示した。しかしながら、３個の受信アンテナを立体的に配置することにより、反射体の三次元的な方位を検出する構成とするさともできる。

【００３９】以上詳細に説明したように、本発明のレーダ装置は、１対の反射波受信手段が受信した反射波の位相、振幅、周波数又は出現時点の差からそれぞれと反射体との間の伝播行路長の差を検出し、この検出した伝播行路長の差から反射体の方位を算定する構成であるから、１対の反射波受信手段で反射体までの距離を算定し、この距離の差から伝播行路長の差を算定する場合に比べて、極めて高精度で反射体の方位を検出できる。

【図面の簡単な説明】

【図１】本発明の一実施例のＡＭレーダ装置の構成を示すブロック図である。

【図２】本発明の他の実施例のＦＭレーダ装置の構成を示すブロック図である。

【図３】本発明の更に他の実施例のパルス・レーダ装置の構成を示すブロック図である。

【図４】本発明の更に他の実施例のレーダ装置の構成を示すブロック図である。

【図５】１個の送信専用のアンテナと２個の受信専用のアンテナの配置と、受信専用の各アンテナと反射体との間の伝播行路長の差δを説明するための概念図である。

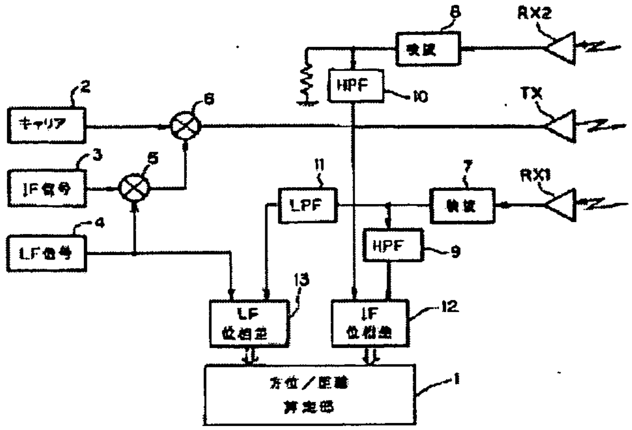
【図６】アンテナ間の距離がＤ、反射体までの距離がＲ、伝播行路長の差がδの場合の反射体の方位を作図によって求める方法を説明するための概念図である。

【図７】図４の実施例における送受共用アンテナと受信専用のアンテナの配置を説明するための概念図である。

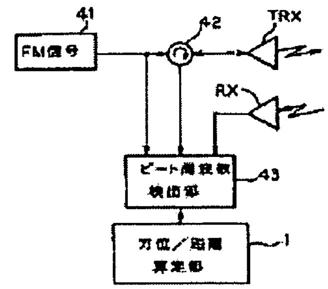
【符号の説明】

TX	送信専用のアンテナ
RX1,RX2	受信専用のアンテナ
TRX	送受共用のアンテナ
１	方位／距離算定部
２	キャリア発生回路
３	ＩＦ信号発生回路
４	ＬＦ信号発生回路
5,6	振幅変調回路
7,8	検波回路
12,13	位相差検出回路

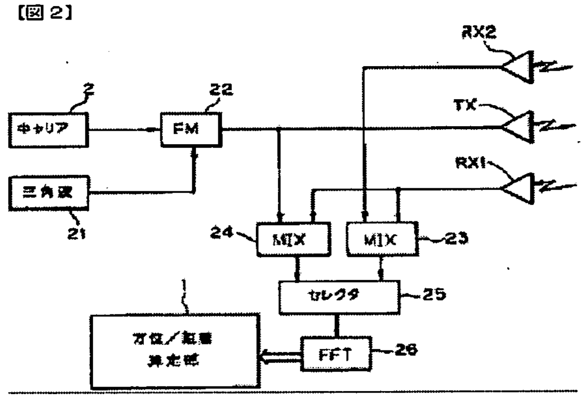
【図1】



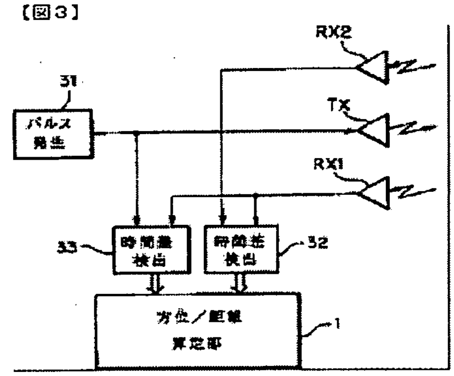
【図4】



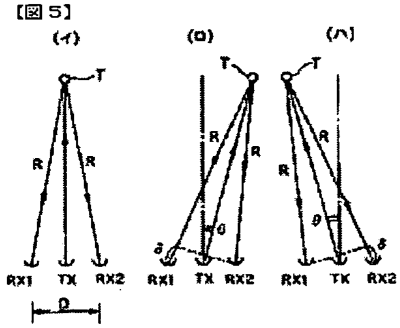
【図2】



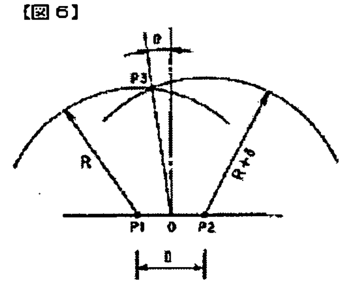
【図3】



【図5】



【図6】



【図7】